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A Diversity antenna for MIMO Application

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Abstract

The Multiple-input Multiple-output (MIMO) antenna system is a vital study in today's Wireless communication system especially when the signal propagates through some corrupted environments. In our paper a new approach of a MIMO antenna is proposed. It is operated in the frequency band of 9.45 GHz. This antenna is suitable to counteract the fading effect caused by multipath propagation. In this design, four numbers of micro strip patch antenna have been placed in the four faces of a rectangular box as shown in the Fig. 1.

Keywords: Antenna diversity; MIMO; Antenna Gain; Mutual coupling

1. Introduction

Over the last two decades the wireless communication system has experienced a significant growth from first generation (1G) to fourth generation (4G). The motto of 4G-communication system is to provide Wi-Fi (wireless fidelity) communication network and high quality audio and video service. Today's technology requires high data rates and longer range to provide quality services to the users. For current mobile communication the diversity scheme has already been implemented to mitigate the fading effects of multipath scenario [1]. In a multipath rich wireless channel, deploying multiple antennas at both the transmitter and receiver achieves high data rate without increasing the total transmission power or bandwidth [2]-[6]. In a MIMO system, the most important parameter is the increase of channel capacity as a result of the use of multiple transmitting and receiving antennas. The capacity of the channel is achieved to grow linearly with the number of antennas. The channel capacity of a MIMO system [3] is given by

$$C = B \log_2 (1 + m_t n_r \, SNR) \qquad (1)$$

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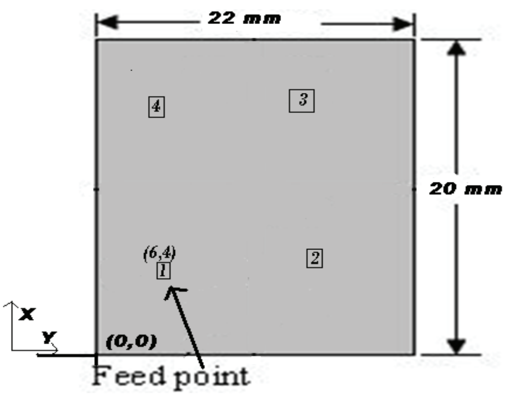
Where B = Band width, SNR = Signal-to-noise, m_t = Number of transmit antenna and n_r = Number of receiving antenna. So MIMO antenna system is very interesting study and it is widely applicable to increase the range and reliability of Wi-Fi LAN, Bluetooth, PDA (Personal Digital Assistants) DCS (Digital communication system) and mostly in the field mobile communication. In our investigation, the MIMO antennas are mounted in the four faces of a rectangular box and the individual antenna has been studied. The antenna has been studied numerically and experimentally.

2. Design Principles

To meet the actual design requirements i.e. operating frequency 9.45GHz, beam pattern, bandwidth and the radiation efficiency, some approximations have been taken. The calculations are based on transmission line model. The width and length of the microstrip patch have been calculated by standard formula [7]. Apart from the calculated values, the dimension of the proposed antenna has been slightly adjusted in order to achieve the desired frequency. Table 1 shows the detail dimensions of the patch, the exact location of the feed point in the Fig. 1. and the geometry of the MIMO antenna structure are illustrated in the Fig. 2.

Table-1

Parameters of the Antenna		Calculated Value	Actual Value
Patch	Width	22.58mm	22mm
	Length	19.91mm	20mm
Substrate	Width	-	30mm
	Length	-	35mm
Finite Ground	Width	-	30mm
	Length	-	35mm



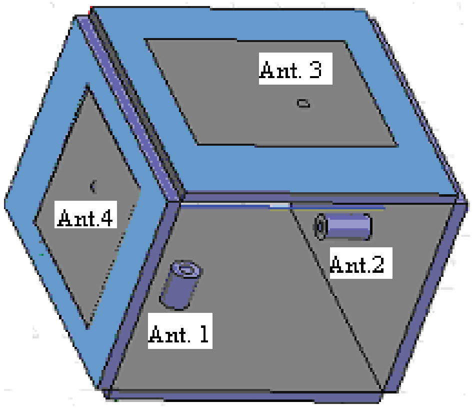


Fig. 1. The feed location of the patch

Fig. 2. Geometry of the MIMO antenna structure

The co-ordinate of the feed point has been fixed at (6, 4). All other points i.e. points 2, 3 and 4 are the image points of 1. The transmission, isolation, reflection and radiation characteristics are the same at all these feed positions shown in the Fig. 2. A number of feed points have been studied in this work but the minimum RL and maximum radiation efficiency has been achieved at the feed location of (6, 4). The characteristics of the array are slightly differ for the other three image points i.e (6,-4), (-6,-4) and (-6,4). It is seen that the antenna performance with other feed locations that are not shown in the Fig.1, is poor. For the fundamental TM_{10} mode, the patch length should be slightly less than $\lambda/2$, where λ is the wavelength in the dielectric medium. Here, λ is equal to $\lambda_0/\sqrt{\varepsilon_o}$, where λ_0 is the free-space wavelength and ε_0 is the effective dielectric constant of the patch. The software used to model and simulate the microstrip patch array is HFSS (High Frequency Structure Simulator). It has been widely used in the design of patch antenna, wire antenna, and other RF/wireless antennas. It can be used to calculate and plot the S- parameters, VSWR, antenna efficiency, current distribution as well as the radiation pattern of any geometrical shaped microstrip patch antenna.

3. Simulated Results

The return loss (RL) and radiation characteristics are the vital study for patch antenna design. Initially a single element has been simulated whose results are shown in the Fig. 3. and Fig. 4. respectively. The return loss and VSWR of the proposed MIMO antenna are shown in the Fig. 5 and Fig. 6 respectively. The E plane pattern of the proposed MIMO antenna is shown in the Fig. 7.

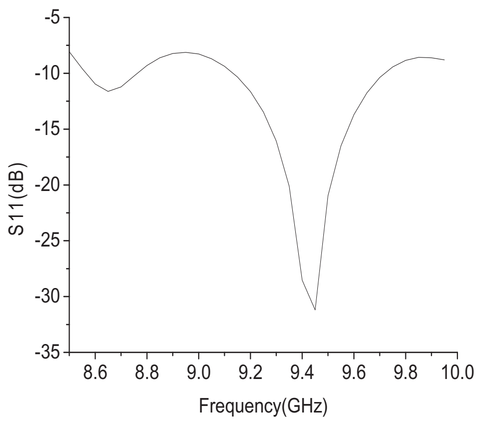


Fig. 3. RL of the single element of the MIMO antenna.

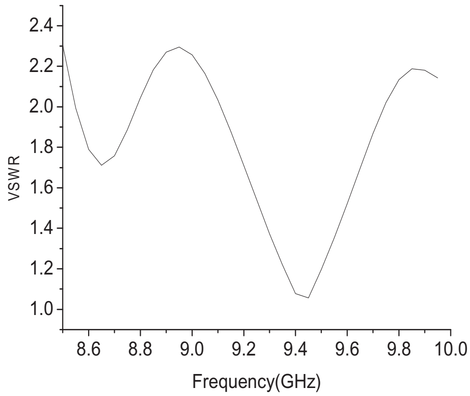


Fig. 4. VSWR of the single element of MIMO antenna.

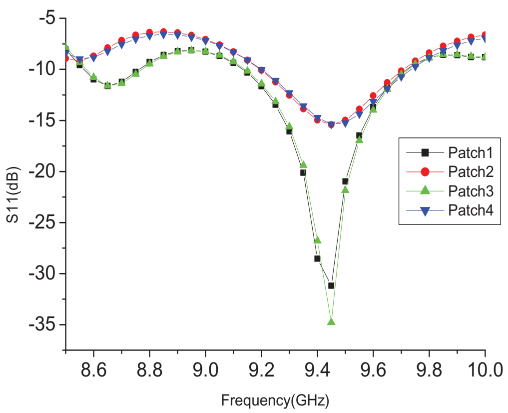


Fig. 5. RL of the proposed MIMO antenna

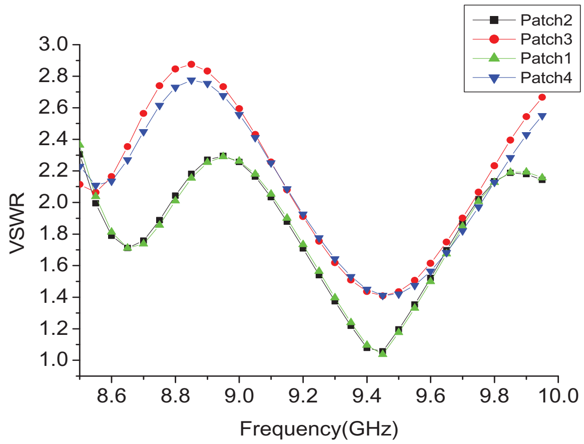


Fig.6. VSWR of the proposed MIMO antenna

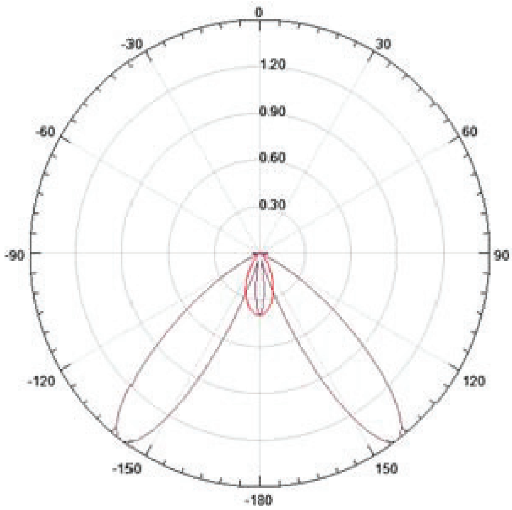


Fig. 7. E- Plane pattern of the proposed MIMO antenna

4. Conclusion

The proposed MIMO antenna is applicable to wireless communication at a frequency of 9.45 GHz. The proposed antenna is electrically small and it is suitable to handle easily. If the dielectric constant is high, the electrical length of the antenna will be reduced but the bandwidth would be narrow. It is clearly observed that the diversity gain of the MIMO antenna is improved significantly. This antenna is useful to counteract the corrupted propagation environment

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